NASA TECHNICAL MEMORANDUM

NASA TM 73727

NASA TM 73727

(NASA-TM-73727) NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPE VL0006 (NASA) 43 p HC A03/MF A01 CSCL 13B

N77-28622

Unclas

G3/45 40729

NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPE VL0006

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July 1977

1. Report No.
NASA TM 73727

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle

NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPE VL0006

5. Report Date

6. Performing Organization Code

7. Author(s)
Daniel J. Gauntner, J. D. Holdeman, and Francis M. Humenik

8. Performing Organization Report No.
E-9284

10. Work Unit No.

9. Performing Organization Name and Address
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
National Aeronautics and Space Administration
Washington, D.C. 20546

13. Type of Report and Period Covered
Technical Memorandum

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The NASA Global Atmospheric Sampling Program (GASP) is obtaining measurements of atmospheric trace constituents in the upper troposphere and lower stratosphere using fully automated air sampling systems on board several commercial B-747 aircraft in routine airline service. Atmospheric ozone, and related flight and meteorological data were obtained during 245 flights of a Qantas Airways of Australia B-747 and two Pan American World Airways B-747s from July 1976 through September 1976. In addition, whole air samples, obtained during three flights, were analyzed for trichlorofluoromethane, and filter samples, obtained during four flights, were analyzed for sulfates, nitrates, fluorides, and chlorides. These data are now available on GASP tape VL0006 from the National Climatic Center, Asheville, North Carolina. In addition to the GASP data, tropopause pressure fields obtained from NMC archives for the dates of the GASP flights are included on the data tape. Flight routes and dates, instrumentation, data processing procedures, data tape specifications, and selected analyses are discussed in this report.

17. Key Words (Suggested by Author(s))
Air quality; Trace constituent measurements; Atmospheric ozone; Chlorofluoromethanes; Filter samples; Troposphere-stratosphere; Meteorology

18. Distribution Statement
Unclassified - unlimited
STAR category 45

19. Security Classif. (of this report)
Unclassified

20. Security Classif. (of this page)
Unclassified

21. No. of Pages

22. Price*

* For sale by the National Technical Information Service, Springfield, Virginia 22161

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SUMMARY

Atmospheric trace constituents in the upper troposphere and lower stratosphere are being measured as part of the NASA Global Atmospheric Sampling Program (GASP), using fully automated air sampling systems on board several commercial B-747 aircraft in routine airline service. Measurements of atmospheric ozone and related meteorological and flight information were obtained during 245 GASP flights from July 8, 1976 through September 26, 1976. Also, bottle samples were obtained during three flights and filters were exposed during four flights. These were analyzed respectively for trichlorofluoromethane and sulfates, nitrates, chlorides, and fluorides. These data are now available from the National Climatic Center, Asheville, North Carolina. In addition to the data from the aircraft, tropopause pressure data obtained from the National Meteorological Center (NMC) archives for the dates of the flights are included. This report is the sixth in a series of reports which describes the data currently available from GASP, including flight routes and dates, instrumentation, data processing procedures, data tape specifications, and selected analyses.

INTRODUCTION

This report announces the availability of atmospheric trace constituent data obtained at altitudes from 6 to 13.5 km during flights of a Qantas Airways of Australia B-747 (VH-EBE) and two Pan American World Airways B-747's (N655PA and N533PA) from July 1976 through September 1976.

The objectives of the NASA Global Atmospheric Sampling Program are to provide baseline data of selected atmospheric constituents in the upper troposphere and lower stratosphere for the next 5-to-10 year period, and to document and analyze these data to assess potential adverse effects from aircraft exhaust emissions on the natural atmosphere. At present there is much uncertainty in environmental impact studies on this subject due to the lack of comprehensive, long-term upper atmospheric data (refs. 1 and 2).

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The GASP program began in 1972 with a feasibility study of the concept of using commercial airliners in routine service to obtain atmospheric data. This program has progressed from design and acquisition of hardware (ref. 3) to collecting global data on a daily basis. Fully automated GASP systems are now operating on a United Airlines B-747, two Pan American World Airways B-747's, a Qantas Airways of Australia B-747, and the NASA CV-990 research aircraft. The United airliner is collecting data over the contiguous United States and between the west coast and Hawaii. Global coverage is provided by the Pan American and Qantas B-747's. The NASA CV-990 aircraft obtains off-commercial route data. Pan Am routes from the United States include around-the-world flights in the Northern Hemisphere, transatlantic flights to Europe, transpacific flights to the Orient, intercontinental flights to Central and South America, and occasionally transpacific flights to Australia. More frequent coverage in the Southern Hemisphere is provided by the Qantas B-747 on transcontinental Australian flights and on flights from Australia to the South Pacific and Australia to Europe. The GASP system design, the measurement instruments, the on-board computer for automatic control and data management, and system maintenance procedures are described in reference 4.

This report is the sixth in a series of reports to announce the availability of GASP data from the National Climatic Center, Asheville, North Carolina, 28801. Northern Hemisphere data for March, 1975 have been previously reported and analyzed (tape VL0001; refs. 5, 6 and 7). Data over the contiguous United States and to Hawaii for March - October, 1975 are provided on GASP tape VL0002 (ref. 8). Data obtained in May, 1975 on flights in North, Central, and South America, and from the United States to the Orient are on tape VL0003 (ref. 9). Global and domestic U.S. data for December, 1975 through June, 1976 are provided on tapes VL0004 and VL0005 (refs. 10 and 11). GASP measurements from July 8 through September 26, 1976 are reported herein. In addition to the atmospheric constituent measurements, the data on this tape, VL0006, include related meteorological and flight information from the aircraft systems, and tropopause pressure fields obtained from the National Meteorological Center (NMC) for the dates of the GASP flights.

ROUTE STRUCTURE AND DATA ACQUISITION

On the tape, GASP data are grouped by aircraft and identified by flights with the airports of departure and arrival designated by the standard three-letter airport codes (ref. 12). A listing of flights on each aircraft data file on tape VL0006 by airport-pair, date, and data

acquisition time, is given in table I. The distribution of the data observations over altitude and latitude is shown in Figure 1. The majority of the data is distributed between flight levels 310 and 410 (9.5 and 12.5 km) and between 20 and 60 degrees North latitude. This distribution reflects the airlines' present scheduling and route structure. The data at flight levels 410 and 430 (12.5 and 13.1 km) are primarily obtained by the B-747SP, which generally flies higher than the regular aircraft. A sizable data base between 20 degrees North and 40 degrees South is due to the Qantas operations.

For each flight, data acquisition begins on ascent through the 6 km altitude flight level, and terminates on descent through 6 km. A complete GASP sampling cycle is 60 minutes, divided into 12 five minute sampling segments. A 16 second recording is made at the end of each five minute sampling segment. During alternate segments (at 10 minute intervals), air sample data are recorded for all instruments. During the intervening segments the system is in one of six different calibration modes to allow for in-flight checks on instrument operation (if required). Whenever any calibration mode is not needed for a given instrument, that instrument acquires air sample data during the segment.

Cassette tapes, recorded in serial format, are removed from the aircraft at approximately two week intervals and transcribed to computer-compatible form for data reduction. At this stage, laboratory instrument calibration information required for data processing is included, redundant and non-usable data are removed, and the data are re-transcribed to final form and units. The detailed specifications and formats for the GASP data are given in appendix A. Data for each flight begins with an FLHT record (table A-I) to provide flight identification information. This record is followed by a series of DATA records (table A-II), one for each recording made during the flight.

MEASUREMENTS

Ozone

Ozone measurements are made using a continuous ultraviolet absorption ozone photometer (ref. 13). The concentration of atmospheric ozone is determined by measuring the difference in intensity of an ultraviolet light beam which alternately passes through the sample gas and an ozone-free zero gas (generated within the instrument). The instrument range is from 3 to 20,000 ppbv (parts per billion by volume), with a sensitivity of 3 ppbv. Data from flight tests of the instrument are given in

reference 14. The ozone instrument is checked at NASA-Lewis (over the range 0 to 1000 ppbv) against an ozone generator which is calibrated by the one percent neutral buffered potassium iodide (KI) method (ref. 15). The estimated accuracy of the KI procedure is seven percent.

In-flight monitoring of the ozone instrument includes measurement of the instrument zero by flowing the sample through a charcoal filter external to the instrument, and measurement of the electronic span setting and control frequencies available from the instrument. For all GASP ozone instruments, the span is set by the manufacturer at 58200 counts. The instrument is not calibrated in-flight with an ozone calibration gas due to the difficulty of generating a precisely known ozone concentration in the flight system. Periodic checks for calibration consistency are performed in the laboratory, as described previously.

The destruction of ozone in the Teflon sample lines from the inlet probe to the instrument, and in the Teflon-coated diaphragm pump that raises the sample pressure up to 100 kPa (1 atm), has been measured under conditions simulating operation in flight. The ozone mixing ratio at the probe inlet (O3, in ppbv) is expressed in terms of the measured ozone mixing ratio (O3m, in ppbv) as

$$O3 = a(O3m)^{b} + \frac{O3m}{1 + c(O3m)} + d \qquad (1)$$

with the constants a, b, c and d determined by a regression analysis on the appropriate destruction test data. For all flights on tape VL0006, the ambient ozone mixing ratios were determined using equation (1) with a = 0.13, b = 1.0 and c = d = 0. This linear relationship between O3 and O3m, and the data from which it was determined are shown in figure 2. The uncertainty in this approximation is $\pm$ 8 percent. The destruction constants used are given in the FLHT record for each flight (see table A-I).

The form chosen for equation (1) is based on the ozone destruction mechanisms expected in the GASP system. If b = 0.5 in the first term, this term then approximates destruction of ozone in the sample lines (c.f. ref. 16). If c > 0 in the second term, this term is of the type which describes thermal decomposition of ozone (refs. 17 and 18). This mechanism could be important in the pump as the sample is heated by the (approximately) 3:1 compression. The percentage of the incoming ozone destroyed by the line mechanism decreases with increasing concentrations, whereas the percentage of the incoming ozone destroyed by the thermal mechanism increases with increasing concentration. Since both mechanisms are likely contributing to the system

destruction, it is not surprising that the destruction data are approximated well with a linear relationship which gives a constant percentage destruction.

Cloud Detector

Flight test experience with the light-scattering particle counters included in the GASP systems has indicated that flight through clouds results in a significantly greater count of the largest size particles (D > 3 micrometers) than is obtained in clear air. A simple cloud detector is thus available by observing the counting rate of the largest size particles. This signal is monitored for 256 seconds prior to each data recording. The time (in seconds) during which the cloud rate, CLDRT, is greater than a preset level, CLDHI, is interpreted as time in clouds (CLSEC; see table A-II). The CLDHI level was programmed on board the United airliner based on visual observation of a light haze, and corresponds to a local particle density (for D > 3 micrometers) of 66,000 particles/cubic meter. If CLSEC > 0, CLTAG = "C". If cloud data are not available, CLTAG = "M".

The number of cloud encounters (CLAYR, see table A-II) is also available. Whenever clouds are detected (CLDRT > CLDHI), this is interpreted as a continuous encounter until cloud-free air is detected. This determination requires a second preset level, CLDLO. If n is the number of times that the cloud rate crosses CLDHI and CLDLO (or CLDLO and CLDHI) in succession, then CLAYR = (n+1)/2. For the data on tape VL0006, CLDLO was set at CLDHI/8.

Flight Data

In addition to the air sample measurements, aircraft flight data are obtained with each data recording to precisely describe conditions when the data are acquired. Aircraft position, heading, and the computed wind speed and direction are obtained from the inertial navigation system. Altitude, air speed, and static air temperature are collected from the central air data computer in the aircraft. Vertical acceleration information (an indication of turbulence) is taken from the aircraft flight recording system. Date and time are provided by a separate GASP clock-calendar unit. The formats and units for these data are given in table A-II.

Filter Samples

Atmospheric concentration data for sulfates, nitrates, chlorides, and fluorides are provided by exposure and

subsequent laboratory analysis of filter samples. Filter exposures are programmed to occur at altitudes greater than 9.6 kilometers on every third calendar day. Whether or not an exposure actually occurs depends on the availability of an unexposed filter. Filters are normally exposed for two hours, although shorter exposures may occur if the aircraft descends to an altitude less than 9.6 kilometers before two hours have elapsed. Filter data are included in the FLHT record (table A-I) for each flight. If an exposure occurs (FILEX = "T") and data from the laboratory analysis are available (FDATA = "T"), the exposure data, time, altitude, the type of filter, and the constitutent data are reported. The data from the laboratory analysis (in micrograms/filter) are divided by the integrated filter flow rate (in ambient cubic meters), and data are reported as micrograms/cubic meter.

Single filter apparatus. The air inlet probe and the filter sampling system are described in reference 4. Briefly, the filter sampling apparatus contains a single filter holder which is inserted into a 7.62 cm diameter duct for sampling, then retracted and stored, all on command from the GASP system control unit. The filter mechanism is stainless steel and is pressure tight. The filter holder can accommodate different types of filter material as appropriate to the atmospheric constituents of interest.

Filter preparation. All filter exposures for which data are reported on tape VL0006 were made using IPC-1478 filter paper. This is a low resistance, cellulose type material made from second cut cotton linters with cotton scrim backing for added strength. This paper was specially designed for high altitude air sampling and thus features low pressure drop, high flow rate, and good retention for small airborne particles. This paper is impregnated with dibutoxyethylphthalate during manufacture to improve collection efficiency.

Prior to use, this paper must be washed to remove residual amounts of water soluble contaminants (ref. 19). Pre-soaking with an acid solution has also been found necessary. For the filters reported herein a 1.0M citric acid solution was used. Using a coarse fritted disc funnel (to support the filter paper), the acid solution is poured onto the filter and momentarily vacuum-drawn through the filter to insure complete wetting. After at least a two minute soaking, the remainder is then vacuum-drawn through the filter until air permeates it. Each filter is then rinsed (vacuum-drawn) with six separate 30-35 ml portions of deionized water saturated with dibutoxyethylphthalate. After overnight vacuum drying, samples from each wash group are analyzed for background levels of contamination to verify the washing procedure.

Upon acceptance, the group of filters is transferred to a clean room for filter holder assembly and sealing. The filters for which data are reported on tape VL0006 were sealed in ultra-clean polyethylene bags to prevent contamination during shipping and handling. After filter exposure and removal from the aircraft, the assembly was re-bagged and carefully re-packaged for return shipment and analysis.

Filter analysis. Prior to analysis, each filter was cut into four equal quarter segments for separate constituent analysis if necessary and for comparative repeat analyses. Sulfate, nitrate, chloride, and fluoride ion concentrations were determined by ion chromatography. The basics of this analysis technique are described in references 20, 21, and 22. This procedure requires wetting a filter segment with 10 ml of carbonate buffer (0.0024M sodium carbonate; and 0.003M sodium bicarbonate) as the extracting solution. A 0.5 ml sample is injected into the ion chromatograph flow system, which includes a carbonate eluent background, an anion separator column, a suppressor column for anion conversion to its acid form, and a conductivity detector.

The instrument is calibrated using solutions with known concentrations of the various anions. Calculations of the anion concentration are made by comparing the constituent peak heights from the sample chromatograms to those obtained with the standard calibrating solution. The fluoride ion identification is still tentative. Further verification is necessary because the possibility of an interferring agent has not been completely eliminated.

The net amount of any constituent on a filter was deduced by subtracting an average background level determined from several reference filter blanks which were removed from unexposed filter holder assemblies. The background levels were lowest for sulfate (approximately 1.6 micrograms per filter) and highest for nitrate (approximately 8.2 micrograms per filter). No other adjustment for any contamination due to handling and shipping was made.

Bottle Samples

Atmospheric concentration data for trichlorofluoromethane (F-11) were obtained by exposure and subsequent laboratory analysis of whole air "grab" samples. Bottle exposures are programmed to occur at altitudes greater than 9.3 kilometers on every third calendar day, provided that an unexposed bottle is available. Bottle data are included in the FLHT record (table A-I) for each flight. If an exposure occurs (SBUEX = "T"), and if data from the laboratory analysis are

available (SDATA = "T"), constituent data are reported in units of parts per trillion by volume (pptv). During a bottle exposure, the GASP system is in a continuous record mode (MODE = "10", see table A-I) to provide a record of the atmospheric conditions which the aircraft encountered during the exposure period.

Sampling system. The sample is taken from a 1.90 cm stainless steel line which is connected to the inlet probe through an expanded duct section. The sample line is continuously purged, with the aid of a bypass line installed just upstream of the sample bottle unit, to clear the duct wall surfaces of possible contamination by adsorbed chlorofluoromethanes.

Each sample bottle unit consists of four one-liter stainless-steel cylindrical sample bottles which have been electropolished, cleaned, and specially prepared for sampling. Hand operated bellows valves are attached at each end of the bottle to form an integral sub-assembly and to facilitate handling and processing procedures. Each sample bottle sub-assembly is connected in series to individual inlet and exit solenoid valves which operate on remote command from the GASP system control unit.

Bottle exposures are normally five minutes in duration. During this time, both the inlet and exit solenoid valves are open. The sampling time was selected to provide more than ten total volume changes to purge the bottle and sample lines prior to trapping the sample. The sample flowrate through the bottle is limited to eight liters/minute by an orifice installed in the exit fitting of the sample bottle unit.

Sample bottle preparation. The bottle sub-assemblies are baked at approximately 300 degrees C for 40 hours or more, during which they are continuously purged with pure helium at a flow rate of 100 standard cc/minute. The final fill pressure is about 172 kPa. At least one bottle from each baked group is pumped down to sub-atmospheric pressure and stored for about a day to allow for wall desorption, and then analyzed for halocarbons. Upon zero level verification, the bottle sub-assemblies are installed in sample bottle units. Each unit is then leak checked with the inlet and exit sample lines evacuated using a helium mass spectrometer leak detector.

Trichlorofluoromethane (F-11) analysis. Bottle samples from which data are included on tape VL0006 were analyzed at Lewis utilizing a gas chromatograph with an electron capture detector. For determining F-11 concentrations, the chromatograph was equipped with a Porasil C column (100-150 mesh, 3.2 mm dia. x 4.0 m long) maintained at a temperature

of 60 degrees C. A sample loop volume of 20 cc at nominally 13 kPa was flushed into the chromatographic column by helium carrier gas flow at about 38 cc/min. The chromatographic retention time was nominally nine minutes. The electron capture detector element was a tritium impregnated scandium foil type maintained at a temperature of 240 degrees C. Instrument sensitivity was determined to be less than 10 pptv.

Calibration was obtained by inter-laboratory comparisons of standards supplied by NOAA Environmental Research Laboratories (Boulder, Colorado) and Washington State University. These standards were derived from the "Halocarbon Analysis and Measurement Techniques Workshop" held at Boulder on March 25-26, 1976. A peak height comparison with these known calibration gases was used to obtain the data included on tape VL0006. Duplicate determinations were made for each sample and the results were averaged. Measurement precision was estimated to be about ± 5 percent.

Sample pressure considerations. Each whole air sample from which data are reported here was obtained at a pressure slightly above the ambient pressure at the exposure altitude. Concern about adsorption-desorption of halocarbon from the walls of the sample containers at low sample pressures has been expressed by participants at the Boulder Workshop, and effects have been observed in recent work at the NOAA Environmental Research Laboratories (ref. 23). Tests at Lewis have shown that when unstable wall conditions exist, they are revealed by the initial zero halocarbon check after storage at low pressure (see Sample bottle preparation). Our tentative conclusion is that the effects are minimal for the sample data reported.

Tropopause Pressure Data

The National Meteorological Center (NMC) is presently maintaining a library of gridded meteorological data fields accessible on various disk and magnetic tape systems (ref. 24). Briefly, the data are interpolated to points on the NMC 65 X 65 grid, a square matrix map transformed from a polar stereographic map of the Northern Hemisphere. Among these gridded data are tropopause pressures, available on a twice daily basis (0000 and 1200 GMT).

The NMC tropopause pressure data arrays are included, when available, for the dates of the GASP flights to provide independent data for analysis of the constituent behavior. The NMC reporting periods for which these data appear on tape VL0006 are given in table II. The tropopause pressure arrays form a separate file (see appendix A) following the

GASP data. Each array (4225 points) is written as seven TRPR records (table A-III). Coordinates for these data are the NMC 65 X 65 matrix. The relations for obtaining latitude and longitude from the NMC coordinates are given in appendix B. The aircraft location for each GASP DATA record is given both in NMC coordinates and latitude and longitude (see table A-II).

The tropopause pressure corresponding to each GASP data location is obtained by time and space interpolation from the NMC arrays. These pressures and the corresponding geopotential heights for the standard atmosphere are included in the GASP DATA records (TRPRMB and TRPRHM in table A-II). For normal interpolations (within a 12 hour interval) TPTAG = " ". If however, NMC data are missing for one reporting period such that the interpolation must be performed within a 24 hour interval, TPTAG is set = "L". If NMC data are missing for two or more consecutive reporting periods the time interpolation is not performed. In this case if the time of the GASP data point is within six hours of an NMC reporting period for which data are available, the space interpolated values at that reporting period are returned and TPTAG is set = "E", but if the time of the GASP data point is not within 6 hours of an NMC reporting period for which data are available, TRPRMB and TRPRHM are set = 0, and TPTAG is set = "M". Whenever tropopause pressure values are available, DELP = TRPRMB - PAMB, and DELHGT = ALTMAV - TRPRHM are also reported.

From September 1974, through mid-December 1975, the location of the tropopause surface archived by NMC was determined by means of the Flattery global analysis method (ref. 25). This procedure made use of the vertical temperature profiles calculated for each NMC grid point, and tested the slope of the profile curve upwards from the first mandatory pressure level. However, as of December 17, 1975, (1200 GMT), the tropopause pressure surface, archived in the NMC 65 x 65 arrays, has been determined using a different analysis scheme. This change adopts a procedure conceived by Gustafson (ref. 26) which attempts to model the tropopause in terms of the potential temperature, which is a meteorologically significant height indicator. The method is based on climatological observations that the tropopause surface is generally in phase with pressure variations along potential temperature surfaces in the lower stratosphere. The modeled tropopause is constrained to lie near various, pre-selected, potential temperature surfaces, depending on month and geographical location.

The Gustafson method first calculates a potential temperature, THETA, profile above each of the 4225 NMC grid points from the ambient temperature, T, at each of the reported pressure levels, p, from the following definition

of the potential temperature:

$$\text{THETA} = (T)(1000/p)^{.2857} \qquad (2)$$

This profile is then scanned downward, and delta THETA/delta p is evaluated for each layer, until a distinct stability transition occurs near the expected THETA location of the mean tropopause. The temperature at the top of this layer is defined as the tropopause temperature. Next, temperatures are calculated upwards from the bottom of the layer assuming pre-selected tropospheric lapse rates (depending on temperature range). The pressure at which this profile attains a temperature equal to the previously determined tropopause temperature is defined as the tropopause pressure. Many details have been omitted from this brief description, and the reader would be best advised to refer to reference 26.

The differences between the tropopause pressures identified by the Gustafson and Flattery methods are significant. These differences are apparent in the monthly zonal averages at 5 degree latitude intervals shown in table III. Here, the values for January through November 1975 were obtained with the Flattery analysis, and values for January through October 1976 were obtained with the Gustafson method. Since the NMC changeover occurred in mid-December 1975, values for that month are a composite. From the table, it is apparent that not only does the current (Gustafson) analysis render tropopause pressures greater than those derived from the previous (Flattery) method, but that the differences increase toward the equator. We believe that the tropopause locations south of 30 degrees N, as reported after December 17, 1975, are suspect, and should be used with caution in analyzing GASP data. North of 30 degrees, the new tropopause pressures seem to fall within the statistical range of observed, mean pressures reported by Reiter (ref. 27) for the North American continent.

SELECTED ANALYSES

During the first nine days in September the variation of local ozone with the Northern Hemisphere mid-latitudes was obtained as the Pan Am B-747SP flew the Los Angeles(LAX) to Tokyo(HND) route three times. The latitude range was obtained because the flight routes, which followed great circles, crossed as much as 24 degrees of latitude even though the latitudes of the two cities differ by less than two degrees. The routes also spanned 100 degrees in longitude and ranged between 10.6 and 13.1 km in altitude. Each flight began at 2000 GMT and ended the following day at

0600 GMT.

Flight records of GASP data, showing NMC tropopause height, flight level, ozone mixing ratio (O3), and static air temperature (SAT) are useful indicators of stratospheric air (e.g.,refs. 6-10). The data from September 2-3 are shown in figure 3. An examination of these data shows ozone levels typical of stratospheric flight between 128 degrees West and 144 degrees East longitude. An independent indicator of stratospheric flight is provided by the difference between the flight level and the tropopause height.

The ozone mixing ratio data are plotted against latitude for the three flights in figure 4. Stratospheric data as determined from the difference between the flight level and the time-and-space interpolated NMC tropopause height are shown as open symbols. These data show the large natural variability in ozone levels at any given latitude.

Ozone data from GASP were shown previously (ref. 11) to be in substantial agreement with the mean ozone data of the North American ozonesonde network (ref. 28). Similar zonal mean ozone values for the GASP September 1976 data are shown in figure 4 for comparison with the local ozone mixing ratios. The mean values were obtained for 5 degree latitude intervals using all data between 10.6 and 13.1 km, the altitude range for the three B-747SP flights. The day-to-day local ozone variation about the zonal mean value is illustrated by the data obtained from the first flight and the third flight at 45 degrees North latitude. The local value obtained on September 3 was 2.6 times the mean value, while the local value for September 9 almost equaled the mean value. This variation is due to local meteorological conditions. Poleward of 45 degrees North latitude the local values are consistently greater that the mean value. This is a consequence of differences in average flight altitudes, in addition to the local meteorological conditions. For these latitudes, the average altitude of the three B-747SP flights was 75 hPa above the tropopause height. The corresponding difference for the GASP September 1976 mean value was 40 hPa above the tropopause. This difference in pressure interval above the tropopause and the corresponding difference between the local ozone data and the September zonal means, are in excellent agreement with the distribution of the January-June 1976 GASP ozone data shown as a function of pressure intervals from the tropopause in reference 11.

The filter analysis data for SO4=, NO3-, Cl-, and Fl- are given in Table IV. Values of 0.000 reported in Table IV indicate analyzed filters having net constituent amounts

less than the background levels. More GASP filter data are needed, however, before any definitive statement can be made regarding constituent concentrations above and below the tropopause.

The GASP sample bottle analyses for F-11 concentrations are shown in Table V. Whenever the location of the exposure altitude with respect to the local tropopause was evident, either from the GASP ozone and temperature data and/or the NMC tropopause pressure data, this information has been entered in the table. The sample pressures shown in Table V are slightly less than total pressure for each exposure. Although the GASP trichlorofluoromethane data are too limited to support any conclusions about variability of this species, it can be observed that the F-11 measurements are within the range of measurements reported in reference 29. The concentrations in bottles 4-3 and 4-4 are representative of stratospheric flight just above the tropopause.

CONCLUDING REMARKS

Atmospheric constituent data and related flight and meteorological data obtained during flights of GASP-equipped Qantas Airways of Australia and Pan American B-747's from July 8, 1976 through September 26, 1976 are now available. Tropopause pressure fields obtained from NMC data archives for the dates of the GASP flights are included as a supplement to the GASP data. These data may be obtained as GASP tape VL0006 from the National Climatic Center, Federal Building, Asheville, NC, 28801. Flight routes and dates, instrumentation, data processing procedures, tape specifications and formats, and selected analyses are discussed in this report.

ACKNOWLEDGEMENTS

The success of GASP of course depends on the dedicated effort of both government and contractor personnel. Specific questions about GASP systems, instrumentation, or data may be addressed to the authors or to any of the NASA Lewis personnel listed below.

GASP system and airline installations	- P. J. Perkins
Ozone measurement	- M. W. Tiefermann
Cloud detector and particle measurement	- T. W. Nyland
Filter preparation and analysis	- D. A. Otterson
Sample bottle preparation and analysis	- G. M. Boyd
Data acquisition system	- T. W. Nyland
Data tape specification and formats	- F. P. Michaelis

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TABLE I - GASP FLIGHTS ON TAPE VL0006

A) FILE 0001 (PANAM -N655PA)

	FLIGHT ROUTE	DEPARTURE DATE	DATA TIME INTERVAL (GMT)	DATA[1]	
1	GIG-JFK	7/11/76	0447-1106	O	
2	JFK-FRA	7/11/76	2252-0457	O	
3	FRA-MUC	7/12/76	0653-0659	O	
4	MUC-FRA	7/12/76	1000-1005	O	
5	FRA-JFK	7/12/76	1228-1911	O	
6	JFK-FRA	7/15/76	2200-0500		F B
7	SFO-HND	8/12/76	2015-0655	O	F
8	HND-HKG	8/13/76	0830-1235	O	
9	HKG-BKK	8/13/76	1400-1745	O	
10	BKK-DEL	8/13/76	1855-2240	O	
11	DEL-THR	8/14/76	2355-0330	O	
12	THR-FRA	8/14/76	0500-1010	O	
13	FRA-LHR	8/14/76	1125-1255	O	
14	LHR-JFK	8/14/76	1415-2150	O	
15	JFK-FCO	8/15/76	0030-0825	O	
16	FCO-JFK	8/15/76	1030-1935	O	
17	JFK-FRA	8/16/76	0045-0810	O	
18	FRA-JFK	8/16/76	0950-1815	O	
19	JFK-LHR	8/17/76	2300-0540	O	
20	LHR-FRA	8/17/76	0800-0925	O	
21	FRA-THR	8/17/76	1030-1520	O	
22	THR-DEL	8/17/76	1655-2015	O	
23	DEL-BKK	8/18/76	2130-0115	O	
24	BKK-HKG	8/18/76	0215-0600	O	
25	HKG-HND	8/19/76	0115-0413	O	
26	HND-SFO	8/19/76	0634-1427	O	
27	SFO-LAX	8/19/76	2341-0006	O	
28	LAX-HNL	8/20/76	0410-0825	O	
29	HNL-NAN	8/20/76	1050-1610	O	
30	NAN-SYD	8/20/76	1753-2138	O	
31	SYD-MEL	8/20/76	2336-0011	O	
32	MEL-SYD	8/21/76	0346-0416	O	
33	SYD-PPG	8/21/76	0628-1038	O	
34	PPG-HNL	8/21/76	1224-1643	O	
35	HNL-LAX	8/21/76	1930-2335	O	
36	LAX-HNL	8/22/76	0337-0807	O	
37	HNL-PPG	8/22/76	1033-1442	O	
38	PPG-SYD	8/22/76	1628-2200	O	
39	SYD-MEL	8/23/76	0014-0051	O	
40	MEL-SYD	8/23/76	0354-0424	O	
41	SYD-PPG	8/23/76	0633-1033	O	
42	PPG-HNL	8/23/76	1214-1635	O	
43	HNL-LAX	8/23/76	1956-2350	O	
44	LAX-HNL	8/24/76	0317-0757	O	
45	HNL-PPG	8/24/76	1016-1427	O	

TABLE I - A) FILE 0001 CONTINUED

	FLIGHT ROUTE	DEPARTURE DATE	DATA TIME INTERVAL (GMT)	DATA[1]	
46	PPG-PPT	8/24/76	1631-1831	O	
47	PPT-PPG	8/25/76	0806-1026	O	
48	PPG-HNL	8/25/76	1201-1626	O	
49	HNL-LAX	8/25/76	2010-0006	O	
50	LAX-HNL	8/26/76	0330-0802	O	
51	HNL-PPG	8/26/76	1034-1445	O	
52	SYD-MEL	8/26/76	2348-0025	O	
53	MEL-SYD	8/27/76	0349-0414	O	
54	SYD-NAN	8/27/76	0628-0918	O	
55	NAN-HNL	8/27/76	1114-1633	O	
56	LAX-HNL	8/28/76	0329-0759	O	
57	HNL-NAN	8/28/76	1025-1534	O	
58	NAN-SYD	8/28/76	1739-2118	O	
59	SYD-MEL	8/28/76	2314-2354	O	
60	MEL-SYD	8/29/76	0347-0416	O	
61	SYD-NAN	8/29/76	0623-0913	O	
62	NAN-HNL	8/29/76	1112-1628	O	
63	HNL-LAX	8/29/76	1931-2353	O	
64	LAX-HNL	8/30/76	0316-0738	O	
65	HNL-PPG	8/30/76	1012-1429	O	
66	PPG-SYD	8/30/76	1930-0054	O	
67	SYD-AKL	8/31/76	0528-0721	O	
68	AKL-HNL	8/31/76	0946-1707	O	
69	HNL-LAX	8/31/76	1943-0003	O	
70	LAX-SFO	9/ 1/76	0149-0204	O	
71	SFO-LAX	9/ 1/76	1456-1521	O	
72	LAX-GUA	9/ 1/76	1810-2149	O	
73	GUA-CCS	9/ 1/76	2353-0220	O	F
74	CCS-GIG	9/ 2/76	0522-1013	O	
75	GIG-VCP	9/ 2/76	1352-1412	O	
76	VCP-GIG	9/ 4/76	0648-0658	O	
77	GIG-PTY	9/ 4/76	0913-1448	O	
78	PTY-GUA	9/ 4/76	1646-1801	O	
79	GUA-LAX	9/ 4/76	2027-0007	O	
80	LAX-SFO	9/ 5/76	0331-0351	O	
81	SFO-HND	9/ 5/76	2050-0634	O	
82	HND-HKG	9/ 6/76	0904-1203	O	
83	HKG-BKK	9/ 6/76	1419-1720	O	
84	BKK-DEL	9/ 6/76	1922-2211	O	
85	DEL-THR	9/ 7/76	0017-0307	O	
86	THR-FRA	9/ 7/76	0538-1015	O	
87	FRA-LHR	9/ 7/76	1158-1228	O	
88	LHR-JFK	9/ 7/76	1443-2101	O	
89	JFK-LHR	9/ 8/76	1431-2011	O	
90	LHR-BRU	9/ 8/76	2148-2153	O	

TABLE I - A) FILE 0001 CONTINUED

	FLIGHT ROUTE	DEPARTURE DATE	DATA TIME INTERVAL (GMT)	DATA[1]
91	BRU-LHR	9/ 9/76	0812-0817	O
92	LHR-JFK	9/ 9/76	1029-1639	O
93	IAD-LHR	9/10/76	0115-0715	O
94	LHR-JFK	9/10/76	1135-1825	O
95	JFK-LHR	9/11/76	1433-2027	O
96	LHR-BRU	9/11/76	2207-2212	O
97	BRU-LHR	9/12/76	0805-0810	O
98	LHR-JFK	9/12/76	1030-1645	O
99	IAD-LHR	9/13/76	0121-0729	O
100	LHR-IAD	9/13/76	1016-1632	O
101	JFK-FRA	9/14/76	0304-0940	O
102	FRA-JFK	9/14/76	1228-1922	O
103	JFK-LHR	9/15/76	0139-0707	O
104	LHR-BOS	9/15/76	1155-1805	O
105	BOS-DTW	9/15/76	1947-2049	O
106	DTW-BOS	9/15/76	2242-2332	O
107	BOS-LHR	9/16/76	0123-0620	O
108	LHR-BOS	9/16/76	1121-1731	O
109	BOS-DTW	9/16/76	1938-2033	O
110	DTW-BOS	9/16/76	2232-2322	O
111	BOS-LHR	9/17/76	0122-0619	O
112	LHR-IAD	9/17/76	1021-1649	O
113	JFK-FRA	9/18/76	0259-0904	O
114	FRA-JFK	9/18/76	1137-1842	O
115	JFK-FRA	9/18/76	2247-0447	O
116	FRA-MUC	9/19/76	0632-0641	O
117	MUC-FRA	9/19/76	0954-0959	O
118	FRA-JFK	9/19/76	1229-1921	O
119	JFK-FCO	9/20/76	0119-0805	O
120	FCO-JFK	9/20/76	1114-1909	O
121	JFK-FCO	9/22/76	0126-0820	O
122	FCO-LHR	9/22/76	1154-1319	O
123	LHR-JFK	9/22/76	1521-2149	O
124	IAD-LHR	9/24/76	0107-0657	O
125	LHR-IAD	9/24/76	1035-1725	O
126	JFK-FRA	9/25/76	0147-0808	O
127	FRA-JFK	9/25/76	1044-1759	O
128	JFK-FRA	9/25/76	2237-0447	O
129	FRA-MUC	9/26/76	0653-0701	O
130	MUC-FRA	9/26/76	0954-0959	O
131	FRA-JFK	9/26/76	1233-1932	O

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1 O - OZONE
F - FILTER EXPOSURE
B - BOTTLE EXPOSURE

TABLE I - GASP FLIGHTS ON TAPE VL0006

B) FILE 0002 (PANAM -N533PA)

	FLIGHT ROUTE	DEPARTURE DATE	DATA TIME INTERVAL (GMT)	DATA[1]	
1	JFK-LHR	7/ 8/76	1440-2020	O	
2	LHR-BRU	7/ 8/76	2144-2154	O	
3	BRU-LHR	7/ 9/76	0805-0810	O	
4	LHR-BOS	7/ 9/76	1108-1647	O	B
5	BOS-DTW	7/ 9/76	1838-1933	O	
6	DTW-BOS	7/ 9/76	2219-2315	O	
7	BOS-LHR	7/10/76	0115-0624	O	
8	LHR-AMS	7/10/76	0929-0934	O	
9	AMS-LHR	7/10/76	1503-1514	O	
10	LHR-JFK	7/10/76	1718-2314	O	
11	JFK-LHR	7/11/76	1444-2020	O	
12	LHR-BRU	7/11/76	2200-2206	O	
13	BRU-LHR	7/12/76	0826-0836	O	
14	LHR-BOS	7/12/76	1118-1658	O	
15	BOS-DTW	7/12/76	1834-1930	O	
16	DTW-BOS	7/12/76	2214-2304	O	
17	BOS-LHR	7/13/76	0104-0621	O	
18	LHR-AMS	7/13/76	0924-0929	O	
19	AMS-LHR	7/13/76	1508-1518	O	
20	LHR-JFK	7/13/76	1726-2326	O	B
21	JFK-HND	7/15/76	1626-0441	O	
22	HND-LAX	7/16/76	1017-1857	O	
23	LAX-HND	7/17/76	2009-0612	O	
24	HND-JFK	7/18/76	0939-2055	O	
25	JFK-LHR	7/19/76	1435-2009	O	
26	LHR-BRU	7/19/76	2151-2201	O	
27	BRU-LHR	7/20/76	0803-0818	O	
28	JFK-LHR	8/26/76	1447-2035	O	
29	LAX-HND	9/ 2/76	2001-0608	O	
30	HND-JFK	9/ 3/76	0958-2059	O	
31	JFK-HND	9/ 4/76	1630-0500	O	
32	HND-LAX	9/ 5/76	0737-1614	O	
33	LAX-HND	9/ 5/76	1959-0610	O	
34	HND-JFK	9/ 6/76	0944-2123	O	
35	JFK-HND	9/ 7/76	1630-0524	O	
36	HND-LAX	9/ 8/76	0738-1645	O	
37	LAX-HND	9/ 8/76	1950-0600	O	
38	HND-JFK	9/ 9/76	0957-2115	O	
39	JFK-ANC	9/10/76	1639-2247	O	
40	ANC-HND	9/11/76	0024-0729	O	
41	HND-JFK	9/11/76	1113-2210	O	
42	JFK-HND	9/12/76	1735-0629	O	
43	HND-JFK	9/13/76	0947-2107	O	
44	JFK-HND	9/14/76	1629-0528	O	
45	HND-LAX	9/15/76	0818-1641	O	

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[1] O - OZONE
B - BOTTLE EXPOSURE

TABLE I - GASP FLIGHTS ON TAPE VL0006

C) FILE 0003 (QANTAS VH-EBE)

	FLIGHT ROUTE	DEPARTURE DATE	DATA TIME INTERVAL (GMT)	DATA[1]
1	SYD-PER	7/13/76	0611-1001	0
2	PER-BOM	7/13/76	1155-1949	0
3	BOM-LHR	7/13/76	2158-0624	0
4	SYD-PER	8/ 3/76	0612-1007	0
5	PER-BOM	8/ 3/76	1309-2059	0
6	BOM-LHR	8/ 3/76	2302-0719	0
7	LHR-BOM	8/ 4/76	1156-1934	0
8	BOM-PER	8/ 4/76	2141-0516	0
9	PER-SYD	8/ 5/76	0702-0955	0
10	SYD-PER	8/ 6/76	0607-1011	0
11	PER-BOM	8/ 6/76	1206-1950	0
12	BOM-LHR	8/ 6/76	2138-0605	0
13	LHR-BOM	8/ 7/76	1151-1931	0
14	BOM-PER	8/ 7/76	2131-0447	0
15	PER-SYD	8/ 8/76	0636-0916	0
16	SYD-MEL	8/ 9/76	0501-0536	0
17	MEL-BKK	8/ 9/76	0729-1603	0
18	BKK-THR	8/ 9/76	1758-2336	0
19	THR-ATH	8/10/76	0119-0404	0
20	ATH-FCO	8/10/76	0551-0656	0
21	FCO-ATH	8/10/76	2125-2220	0
22	ATH-THR	8/11/76	0000-0240	0
23	THR-BKK	8/11/76	0437-1022	0
24	BKK-MEL	8/11/76	1232-2023	0
25	MEL-SYD	8/11/76	2210-2235	0
26	SYD-MEL	8/14/76	0358-0433	0
27	MEL-BKK	8/14/76	0624-1439	0
28	BKK-THR	8/14/76	1645-2233	0
29	THR-ATH	8/15/76	0017-0310	0
30	ATH-FCO	8/15/76	0509-0614	0
31	FCO-ATH	8/15/76	1847-1943	0
32	ATH-THR	8/15/76	2132-0012	0
33	THR-BKK	8/16/76	0212-0757	0
34	BKK-MEL	8/16/76	1046-1808	0
35	MEL-SYD	8/16/76	2002-2032	0
36	SYD-MNL	8/17/76	0126-0804	0
37	MNL-HKG	8/17/76	0949-1049	0
38	HKG-MNL	8/17/76	1308-1403	0
39	MNL-SYD	8/17/76	1552-2227	0
40	SYD-DRW	8/18/76	0612-0932	0
41	DRW-BKK	8/18/76	1128-1613	0
42	BKK-DAM	8/18/76	1832-0137	0
43	DAM-ATH	8/19/76	0316-0451	0
44	ATH-BEG	8/19/76	0640-0715	0
45	BEG-ORY	8/19/76	0842-1002	0

TABLE I - C) FILE 0003 CONTINUED

	FLIGHT ROUTE	DEPARTURE DATE	DATA TIME INTERVAL (GMT)	DATA[1]
46	ORY-BEG	8/19/76	1543-1708	O
47	BEG-ATH	8/19/76	1849-1929	O
48	ATH-DEL	8/19/76	2205-0315	O
49	DEL-BKK	8/20/76	0513-0808	O
50	BKK-DRW	8/20/76	1115-1610	O
51	DRW-SYD	8/20/76	1828-2123	O
52	SYD-BKK	8/22/76	1042-1959	O
53	BKK-ATH	8/22/76	2203-0704	O
54	ATH-LHR	8/23/76	0857-1133	O
55	LHR-ATH	8/23/76	1631-1901	O
56	ATH-BKK	8/23/76	2131-0639	O
57	BKK-MEL	8/24/76	0919-1659	O
58	MEL-SYD	8/24/76	1905-1945	O
59	SYD-NOU	8/25/76	0052-0236	O
60	NOU-SYD	8/25/76	0447-0702	O
61	SYD-CHC	8/26/76	0434-0634	O
62	CHC-SYD	8/26/76	0905-1120	O
63	SYD-BKK	8/29/76	1053-1938	O
64	BKK-ATH	8/29/76	2142-0650	O
65	ATH-LHR	8/30/76	0835-1100	O
66	LHR-ATH	8/30/76	1634-1859	O
67	ATH-BKK	8/30/76	2132-0625	O
68	BKK-MEL	8/31/76	0934-1704	O
69	MEL-SYD	8/31/76	1909-1939	O

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1 O - OZONE

TABLE II - NMC TROPOPAUSE PRESSURE DATA ON GASP TAPE VL0006, FILE 4

	From	Through
1	7/08/76, 1200 GMT	7/20/76, 1200 GMT
2	8/03/76, 0000 GMT	9/29/76, 0000 GMT

Table III - Zonal Averaged NMC Tropopause Pressure Data, January 1975 - October 1976
(Data expressed in hPa)

Year	Month	20	25	30	35	40	45	50	55	60	65	70	75	80	85
		LATITUDE (Degrees North)													
1975	J	131.5	138.3	165.5	210.6	234.6	243.9	253.5	262.1	267.4	268.1	264.5	260.8	256.9	251.8
1975	F	134.3	153.5	189.5	223.6	241.3	254.1	262.6	265.1	264.4	262.0	261.8	264.8	265.9	264.3
1975	M	132.6	149.0	183.2	212.8	228.7	242.9	255.3	262.9	268.1	274.3	281.5	286.7	287.5	285.1
1975	A	134.0	145.2	169.3	195.4	212.9	226.0	239.3	251.3	262.7	275.0	287.9	299.4	306.5	308.7
1975	M	130.2	135.1	154.9	184.9	207.1	221.7	234.9	247.0	258.6	269.3	278.0	286.6	297.2	304.9
1975	J	130.2	130.7	135.4	152.3	180.3	205.7	220.8	232.2	244.9	256.7	267.4	277.1	281.9	280.8
1975	J	130.3	130.5	130.6	133.9	150.7	182.7	213.0	229.1	235.9	242.8	252.8	261.4	265.7	267.2
1975	A	130.4	130.8	131.1	133.9	148.7	179.8	211.1	227.9	235.4	240.5	247.0	256.0	265.2	270.8
1975	S	130.3	131.0	132.1	137.7	158.2	191.6	218.4	232.7	242.2	251.5	262.5	272.4	276.6	275.1
1975	O	132.0	132.8	136.4	151.8	182.3	215.4	237.5	247.0	251.4	257.7	267.7	277.9	286.3	292.1
1975	N	131.1	134.4	145.1	172.2	201.9	223.0	239.0	252.2	263.0	270.3	273.6	275.7	279.9	285.5
1975	D	155.3	165.3	190.0	226.0	251.5	261.9	268.0	273.3	278.1	282.0	284.8	286.3	287.1	288.5
1976	J	192.0	209.3	237.0	267.4	286.2	292.4	295.8	298.9	298.6	294.2	288.4	285.3	283.1	277.6
1976	F	192.6	211.0	242.6	266.5	280.2	293.9	305.1	307.8	302.2	294.2	287.6	282.5	280.5	280.3
1976	M	187.6	204.1	232.8	255.5	274.2	292.8	306.7	312.0	310.7	302.9	292.2	284.2	280.5	278.7
1976	A	181.7	191.9	214.3	236.4	255.5	273.6	287.9	298.7	308.8	319.2	328.4	334.8	334.4	329.3
1976	M	179.4	186.7	202.8	221.1	239.6	258.8	277.5	294.9	308.0	315.7	322.8	332.8	341.5	344.9
1976	J	176.2	184.8	194.8	207.3	225.8	246.0	262.6	277.3	289.2	300.2	313.5	325.3	330.0	327.5
1976	J	160.2	172.7	183.6	194.7	212.3	234.8	255.8	266.7	273.3	283.4	296.6	308.1	317.9	326.6
1976	A	150.3	160.5	172.3	185.7	206.0	232.1	252.7	264.6	272.5	279.7	291.0	307.9	324.9	334.2
1976	S	165.2	173.4	184.2	196.4	215.9	237.2	255.2	269.2	278.8	286.5	294.4	303.0	313.4	323.9
1976	O	172.3	175.1	185.5	204.1	221.6	241.2	265.9	287.5	297.8	301.6	303.8	306.3	312.3	322.1

MONTH

TABLE IV - FILTER DATA ON TAPE VL0006

GASP Identification				
Filter no.	712	514	422	516
File, flight	1,6	1,7	1,73	*
Exposure Data				
Date	7/15/76	8/13/76	9/02/76	9/20/76
Latitude, deg	52-52N	56-57N	12-11N	42-42N
Longitude, deg	35-7W	152-177W	81-68W	77-95W
Time, min	120	120	86(14,72)	120(65,55)
Altitude, km	11.3	10.1	10.7,11.3	10.7,11.9
Region	uncertain	uncertain	troposphere	*
Constituent Data				
SO4=, $\mu g/m^3$	0.148	0.067	0.051	0.053
NO3-, "	0.096	0.072	0.140	0.060
Cl- , "	0.000	0.000	0.023	0.002
F- , "	0.000	0.004	0.004	0.000

* Flight data not available

TABLE V - SAMPLE BOTTLE DATA ON TAPE VL0006

GASP Identification			
Bottle no.	4-3	4-4	10-1
Analysis no.	117	128	220
File, flight	2,4	2,20	1,6
Sample Data			
Date	7/09/76	7/13/76	7/15/76
Latitude, deg	54N	54N	52N
Longitude, deg	5W	5W	34W
Altitude, km	11.9	11.9	11.3
Region	stratosphere	stratosphere	uncertain
Pressure, kPa	30	30	31
Constituent Data			
F-11, pptv	100	100	143

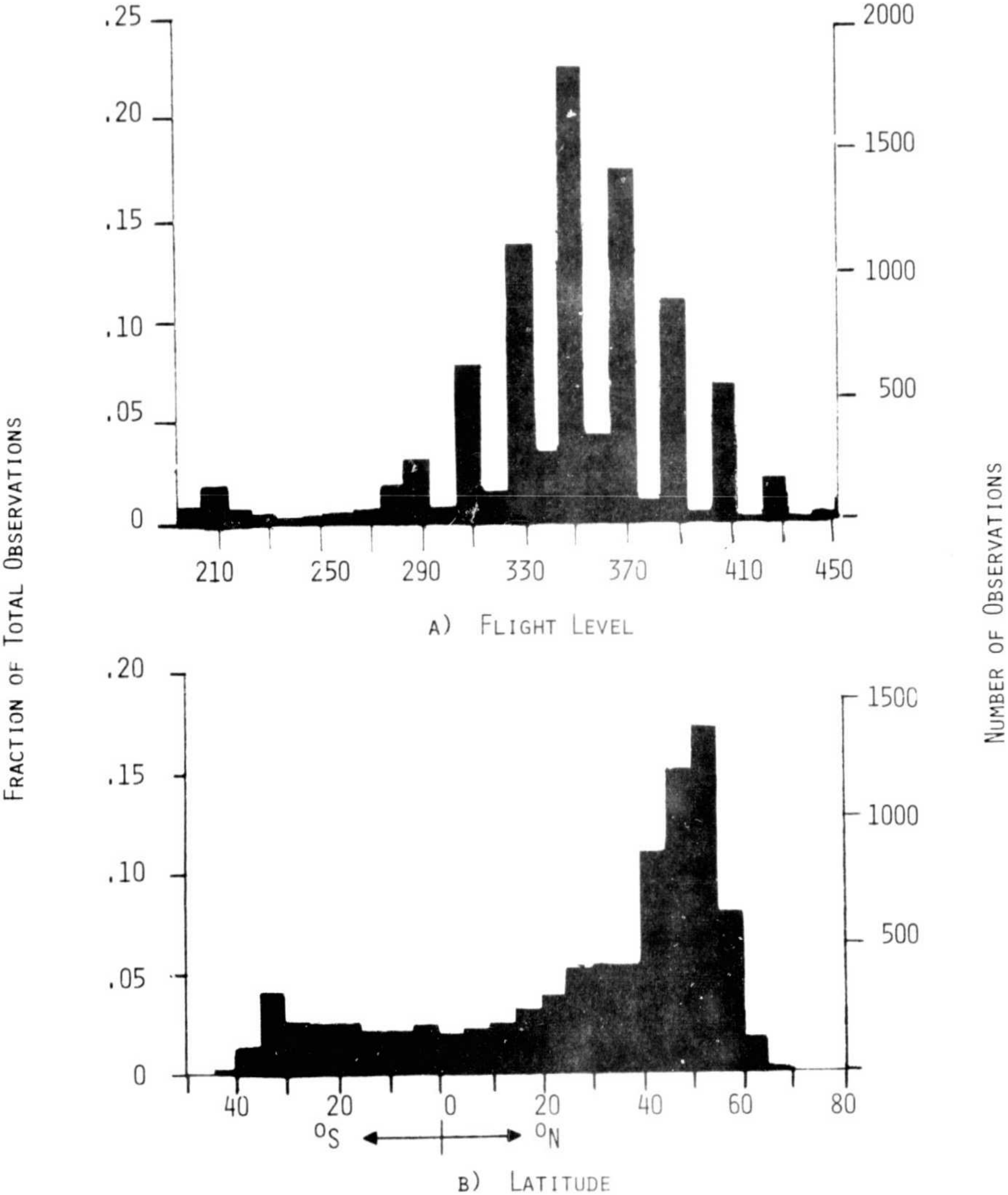

Figure 1 - Distribution of GASP VL0006 Data, July - September 1976

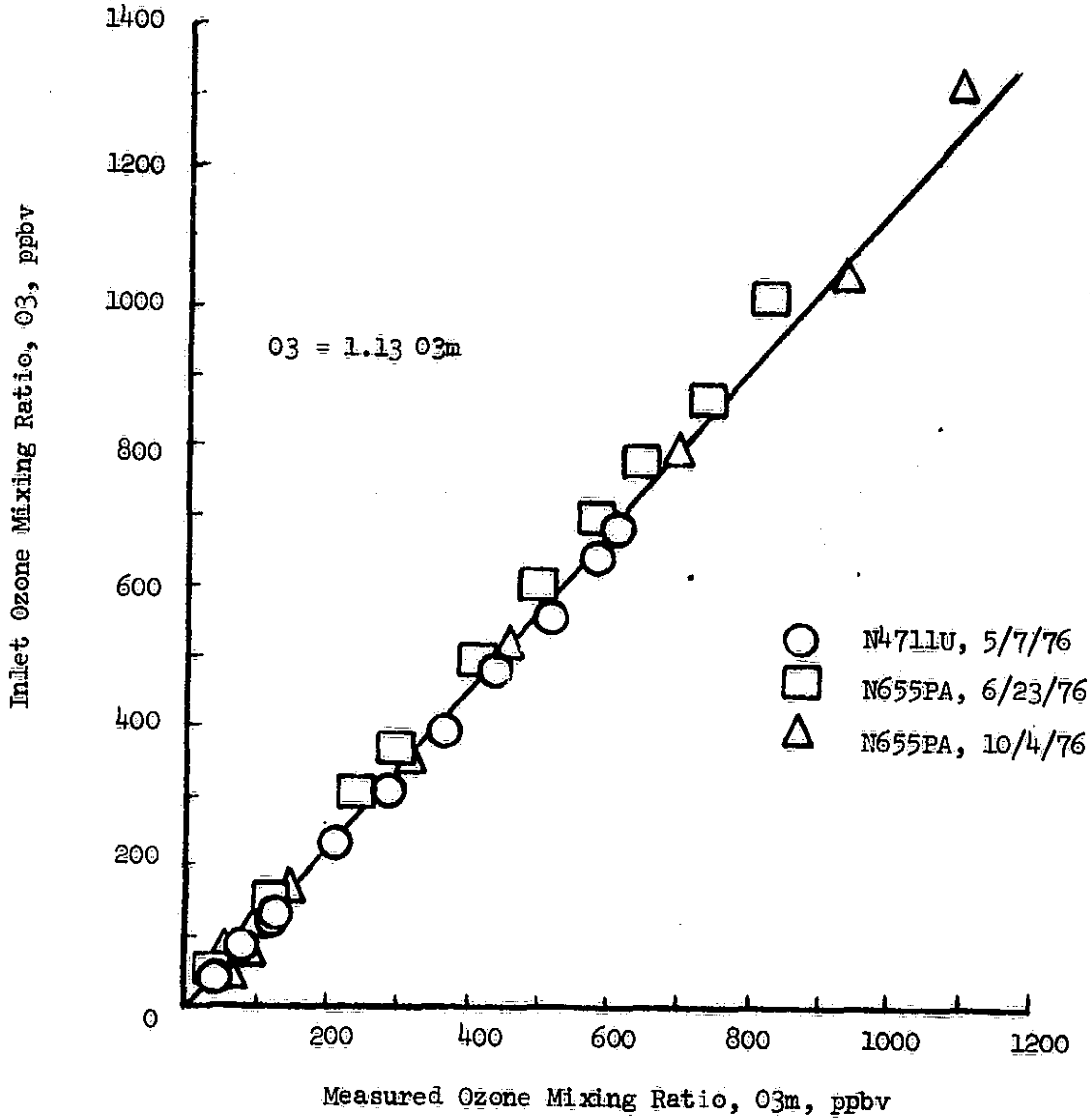

Figure 2 - GASP System Ozone Destruction Test Results Used for VL0006

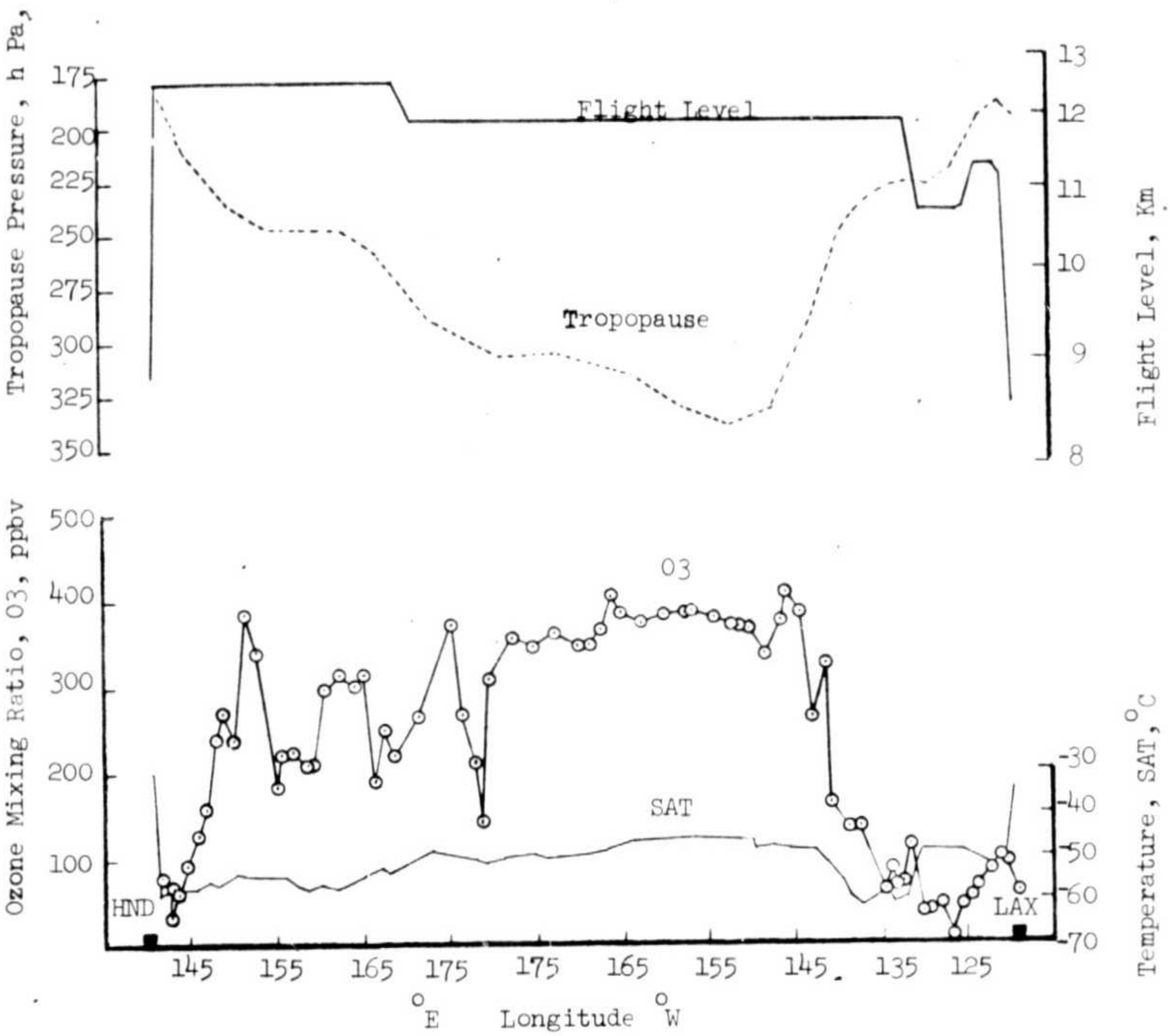

Figure 3 - Flight record for September 2-3, 1976. All data are from GASP and aircraft systems except for the tropopause pressures which are from time and space interpolations from NMC data archives.

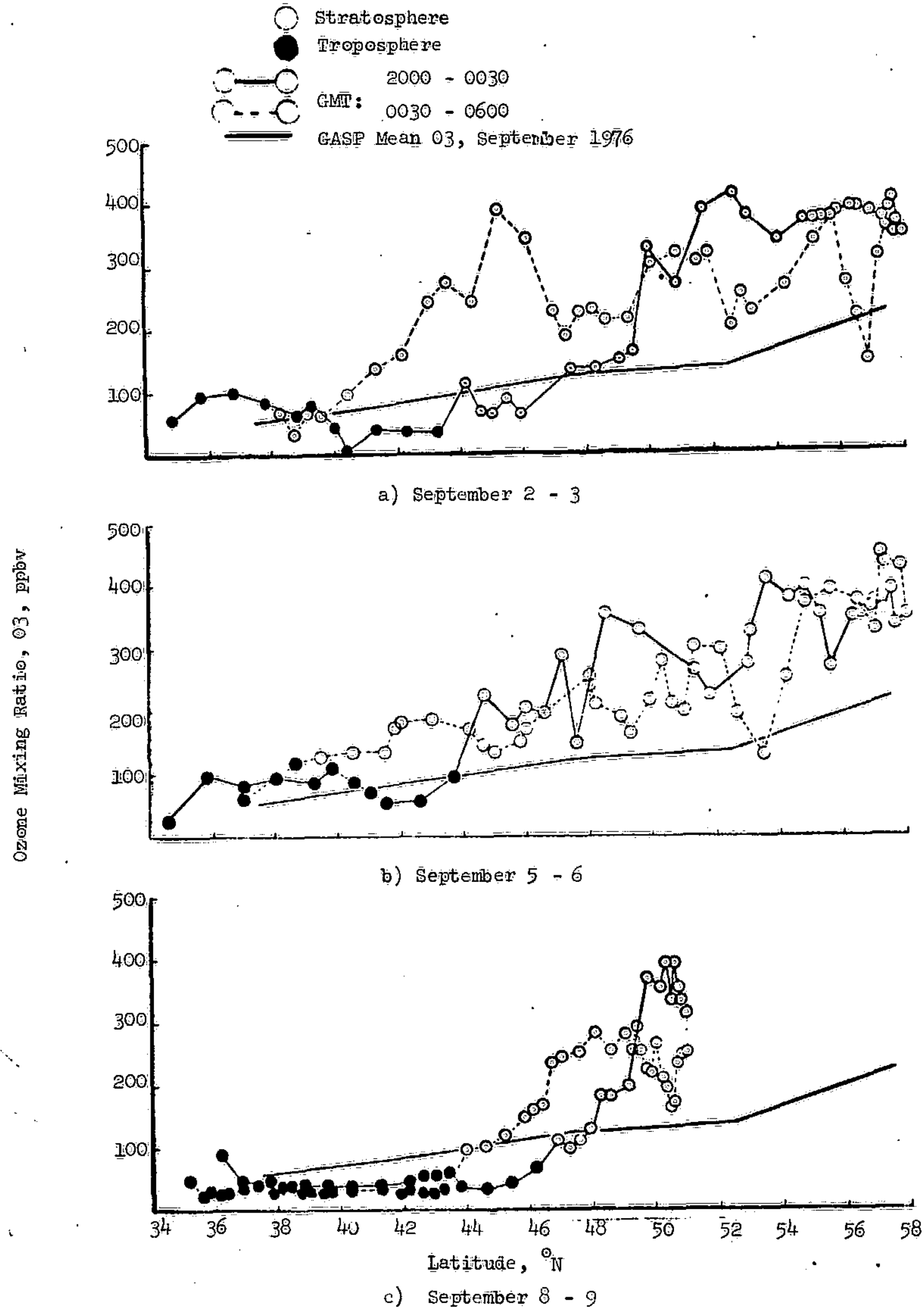

Figure 4 - Latitudinal variation of ozone mixing ratio over the northern Pacific Ocean for early September 1976

APPENDIX A - Specifications for GASP Archive Tapes (VLXXXX)

GENERAL

1. Tapes are written in EBCDIC format using nine track tapes.

2. Tape density is 800 BPI.

3. Physical records (blocks) are 4096 bytes.

4. The tapes are unlabeled, and contain one or more GASP data files followed by a tropopause pressure data file.

GASP DATA FILE

1. Each GASP data file contains data from a single GASP aircraft. Within each file, data are grouped and identified by flights (takeoff to landing) in chronological order.

2. The GASP data for each flight begins with a logical FLHT record (flight identification data), which is followed by logical DATA records (one for each data recording made during the flight). Both FLHT and DATA records contain 512 bytes, hence there are 8 logical records per physical record (block).

3. A FLHT record will always be the first logical record in a block. However, every block need not begin with a FLHT record (i.e., if there are more than seven DATA records in a flight). If the FLHT record plus the available DATA records for a flight do not fill an integer number of blocks, the unused logical records in the final block are padded with zeros creating PADD records. The diagram below shows how several short flights would be blocked.

Block	1								2								3							
	F	D	D	D	D	D	P	P	F	D	D	D	D	D	D	D	D	D	P	P	P	P	P	P
Logical Record	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8

Block	4	5	6
	F D D D D D D D	D D D D D D D D	F D D D D D D P
Logical Record	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8

where F is a FLHT record
D is a DATA record
P is a PADD record

4. The first four bytes in each logical record identify the record type as FLHT, DATA, or PADD. Detailed specification of the parameters and formats for FLHT and DATA records are given in Table A-I and A-II respectively.

   a) In each FLHT record, the number of DATA records to follow is given by NDATA (Bytes 78-81), and the number of blocks in the flight is given by NBLOCK (Bytes 82-84).
   b) For the last DATA record of each flight, LBFLG (Byte 5) = "L"; for the last DATA record in each file, LBFLG = "G" if the following file is a GASP data file, and LBFLG = "T" if the following file is the tropopause pressure file; for all other DATA records, LBFLG = " ".

   Note: DATA records with LBFLG ≠ " " will be followed by PADD records if the physical record (block) is not complete.

TROPOPAUSE PRESSURE DATA FILE

1. Following the GASP data, in a separate file, tropopause pressure data for the dates of the GASP flights are included. Data are currently available from the National Meteorological Center (NMC) twice daily for 4225 locations in the Northern Hemisphere. Coordinates for these data are the NMC 65X65 square matrix grid, transformed from a polar stereographic map of the Northern Hemisphere.

2. Each 65X65 tropopause pressure array is written as seven TRPR records. Each TRPR record is a physical record (block), and is the same length as the GASP physical records (4096 bytes). All TRPR records contain identification information. Specifications and formats for the TRPR records are given in Table A-III.

Table A-I Format for FLHT Records

Bytes	Fortran Name	Fortran Format	Parameter Description, Units, and Comments
1-4	RECID	A4	RECID = "FLHT"
5-10	TAPID	A6	Original GASP tape number, GPXXX
11-25	ACID	A15	Aircraft ID; Airline and tail number
26-28	APTLV	A3	Airport of departure (3 letter code)
29-34	DATLV	3I2	Date first DATA record this flight; Mo=29-30, Da=31-32, Yr=33-34
35-38	TIMLV	2A2	Time (GMT) first DATA record this flight; Hr=35-36, Min=37-38
39-43	LATLV	F5.2	Latitude (deg) of APTLV
44	LALVT	A1	Hemisphere of LATLV; "N" or "S"
45-50	LONLV	F6.2	Longitude (deg) of APTLV
51	LOLVT	A1	Hemisphere of LONLV; "E" or "W"
52-54	APTAR	A3	Airport of arrival (3 letter code)
55-60	DATAR	3I2	Date last DATA record this flight; Mo=55-56, Da=57-58, Yr=59-60
61-64	TIMAR	2A2	Time (GMT) last DATA record this flight; Hr=61-62, Min=63-64
65-69	LATAR	F5.2	Latitude (deg) of APTAR
70	LAART	A1	Hemisphere of LATAR, "N" or "S"
71-76	LONAR	F6.2	Longitude (deg) of APTAR
77	LOART	A1	Hemisphere of LONAR, "E" or "W"
78-81	NDATA	I4	Number of DATA records for this flight
82-84	NBLOCK	I3	Total number of blocks for this flight
85-87	O3ID	A3	Ozone instrument ID number*
88-90	COID	A3	Carbon monoxide instrument ID number*
91-93	PCSID	A3	Particle counter sensor ID number*
94-96	PCEID	A3	Particle counter electronics ID number*
97-99	H2OID	A3	Water vapor sensor ID number*
100-102	HYGID	A3	Hygrometer ID number*
103-105		A3	Spare ID
106-108		A3	Spare ID
109-111		A3	Spare ID
112-114		A3	Spare ID

Table A-I Continued

Bytes	Fortran Name	Fortran Format	Parameter Description, Units, and Comments
115-117		A3	Spare ID
118-122	D1	F5.3	Smallest particle radius (micrometers) for PC range 1
123-127	D2	F5.3	Smallest particle radius (micrometers) for PC range 2
128-132	D3	F5.3	Smallest particle radius (micrometers) for PC range 3
133-137	D4	F5.3	Smallest particle radius (micrometers) for PC range 4
138-142	D5	F5.3	Smallest particle radius (micrometers) for PC range 5
143	LIMCHK	A1	LIMCHK="T" if ACC limit exceeded (NE .GT. 0) on any DATA record this flight; otherwise LIMCHK="F"
144	FILEX	A1	FILEX="T" if filter exposed this flight; otherwise FILEX="F"
145	FDATA	A1	FDATA="T" if filter data on tape; otherwise FDATA="F"
146-149	FPAKN	I4	Filter pack number
150-151	FILTN	I2	Filter number
152-161	FTYPE	A10	Filter type
162-167	FDATON	3I2	Filter exposure start date; Mo=162-163, Da=164-165, Yr=166-167
168-171	FTIMON	2A2	Filter exposure start time; (GMT); Hr=168-169, Min 170-171
172-176	FLATON	F5.2	Filter exposure start latitude (deg)
177	FLAONT	A1	Filter exposure start latitude tag; "N" or "S"
178-183	FLONON	F6.2	Filter exposure start longitude (deg)
184	FLOONT	A1	Filter exposure start longitude tag; "E" or "W"
185-190	FHTMON	F6.0	Filter exposure start altitude (meters)
191-196	FDATOF	3I2	Filter exposure stop date; Mo=191-192, Da=193-194, Yr=195-196
197-200	FTIMOF	2A2	Filter exposure stop time (GMT); Hr=197-198, Min=199-200
201-205	FLATOF	F5.2	Filter exposure stop latitude (deg)
206	FLAOFT	A1	Filter exposure stop latitude tag; "N" or "S"
207-212	FLONOF	F6.2	Filter exposure stop longitude (deg)
213	FLOOFT	A1	Filter exposure stop longitude tag; "E" or "W"
214-219	FHTMOF	F6.0	Filter exposure stop altitude (meters)
220-229	FCOMP1	A10	Filter constituent 1 (name)
230-239	FCOMP2	A10	Filter constituent 2 "

Table A-I Continued

Bytes	Fortran Name	Fortran Format	Parameter Description, Units, and Comments
240-249	FCOMP3	A10	Filter constituent 3 "
250-259	FCOMP4	A10	Filter constituent 4 "
260-269	FCOMP5	A10	Filter constituent 5 "
270-279	FDC1	F10.3	Data for constituent 1 (micrograms/M**3)
280-289	FDC2	F10.3	Data for constituent 2 (micrograms/M**3)
290-299	FDC3	F10.3	Data for constituent 3 (micrograms/M**3)
300-309	FDC4	F10.3	Data for constituent 4 (micrograms/M**3)
310-319	FDC5	F10.3	Data for constituent 5 (micrograms/M**3)
320	SBUEX	A1	SBUEX="T" if bottle exposed this flight, otherwise SBUEX="F"
321	SDATA	A1	SDATA="T" if bottle data on tape; otherwise SDATA="F"
322-324	SBID	I3	Sample bottle unit number
325-326	STBN	I2	Bottle number
327-332	SDATON	3I2	Bottle exposure start date; Mo=327-328, DA=329-330, Yr=331-332
333-336	STIMON	2A2	Bottle exposure start time (GMT); Hr=333-334, Min=335-336
337-341	SLATON	F5.2	Bottle exposure start latitude (deg)
342	SLAONT	A1	Bottle exposure start latitude tag, "N" or "S"
343-348	SLONON	F6.2	Bottle exposure start longitude (deg)
349	SLOONT	A1	Bottle exposure start longitude tag "E" or "W"
350-355	SHTMON	F6.0	Bottle exposure start altitude (meters)
356-361	SDATOF	3I2	Bottle exposure stop date; Mo=356-357, DA=358-359, Yr=360-361
362-365	STIMOF	2A2	Bottle exposure stop time (GMT); Hr=362-363, Min=364-365
366-370	SLATOF	F5.2	Bottle exposure stop latitude (deg)
371	SLAOFT	A1	Bottle exposure stop latitude tag; "N" or "S"
372-377	SLONOF	F6.2	Bottle exposure stop longitude (deg)
378	SLOOFT	A1	Bottle exposure stop longitude tag; "E" or "W"
379-384	SHTMOF	F6.0	Bottle exposure stop altitude (meters)
385-394	SCOMP1	A10	Bottle constituent 1 (name)
395-404	SCOMP2	A10	Bottle constituent 2 "
405-414	SCOMP3	A10	Bottle constituent 3 "

Table A-I Completed

Bytes	Fortran Name	Fortran Format	Parameter Description, Units, and Comments
415-424	SCOMP4	A10	Bottle constituent 4 "
425-434	SCOMP5	A10	Bottle constituent 5 "
435-444	SDC1	F10.1	Data for constituent 1 (PPTV)
445-454	SDC2	F10.1	Data for constituent 2 "
455-464	SDC3	F10.1	Data for constituent 3 "
465-474	SDC4	F10.1	Data for constituent 4 "
475-484	SDC5	F10.1	Data for constituent 5 "
485-489	a	F5.3	O3 destruction constant (see eq. 1)
490-494	b	F5.3	O3 destruction constant (see eq. 1)
495-499	c	F5.1	O3 destruction constant (see eq. 1)
500-507	d	E8.2	O3 destruction constant (see eq. 1)
508-512		5A1	Spares

*if ID="M", no data for this instrument this flight

Table A-II Format for DATA Records

Bytes	Fortran Name	Fortran Format	Parameter Description, Units, and Comments
1-4	RECID	A4	RECID= "DATA"
5	LBFLG	A1	LBFLG="L" if this is the last data record this flight; LBFLG="G" If this is the last GASP data record in the file and the following file is a GASP data file; LBFLG="T" If this is the last GASP data record in the file and the following file is a tropopause pressure file; otherwise LBFLG=" "
6-9	RECORD	I4	Record number on TAPID
10	FRAME	I1	Frame number on TAPID
11-12	MODE	I2	Program mode from DMCU MODE = 4 identifies a normal recording MODE = 10 identifies a continuous recording
13	TYPE	A1	Record type from DMCU
14	CYCLE	A1	Cal set up from DMCU
15-20	DATE	3I2	Mo=15-16, Da=17-18, Yr=19-20
21-24	TIME	2A2	(GMT), Hr=21-22, Min=23-24
25-30	ALTFAV	F6.0	Altitude (ft)
31-36	ALTMAV	F6.0	Altitude (meters)
37-43	PAMB	F7.2	Ambient static pressure in hectopascals (mb) - calc from ALTFAV
44	ALTAG	A1	ALTAG="C", "D", or "G" indicates climb, descent, or ground
45-49	LAT	F5.2	Latitude (deg)
50	LATAG	A1	Latitude hemisphere, "N" or "S"
51-56	LONG	F6.2	Longitude (deg)
57	LONGTAG	A1	Longitude hemisphere, "E" or "W"
58-62	XI	F5.2	Aircraft position in NMC grid coordinates
63-67	YJ	F5.2	Aircraft position in NMC grid coordinates
68-71	HEADG	F4.0	Aircraft heading (deg)

Table A-II Continued

Bytes	Fortran Name	Fortran Format	Parameter Description, Units, and Comments
72	HEADGT	A1	Tag for HEADG*
73-76	TASK	F4.0	True airspeed (knots)
77-81	XMATAS	F5.3	Flight mach number
82	TATAG	A1	Tag for TASK and XMATAS*
83-86	WS	F4.0	Wind speed (knots)
87-90	WSM	F4.0	Wind speed (meters/sec)
91	WSTAG	A1	Tag for WS and WSM*
92-95	WDEG	F4.0	Wind direction (deg)
96	WDEGTG	A1	Tag for WDEG*
97-100	SAT	F4.0	Static (ambient) air temperature (deg C)
101	SATAG	A1	Tag for SAT*
102-229	ACC(I)	32F4.2	Aircraft acceleration (gs); 32 values each record at 8/sec
230-233	ACCMAX	F4.2	Max of ACC(I)
234-237	ACCMIN	F4.2	Min of ACC(I)
238-239	NE	I2	Number of times ACC(I) > 1.2 or ACC(I) < 0.8
240	ACCTAG	A1	Tag for ACC(I), ACCMAX, ACCMIN, NE*
241-245	ZEN	F5.1	Solar elevation angle (deg); 0 deg = horizontal
246	SUNTAG	A1	SUNTAG="N" if sun below horizon
247-252	O3	F6.0	Ozone data (PPBV)
253	O3TAG	A1	Tag for O3*
254-259	O3A	F6.0	Ozone data (PPBV); ave for 128 sec preceding recording
260	O3ATAG	A1	Tag for O3A*
261-266	O3S	F6.0	Ozone std deviation (PPBV); for 128 sec preceding recording
267	O3STAG	A1	Tag for O3S*
268-273	DFPTA	F6.1	Dew/frost point temperature (deg C)
274-279	WVMRA	F6.1	Water vapor mixing ratio (PPMW)
280	DFTAGA	A1	Tag for DFPTA and WVMRA; if DFPTA=SAT, DFTAGA="S"*
281-286	COAVG	F6.3	Carbon monoxide data (PPMV)
287	COTAGA	A1	Tag for COAVG*
288-293	COA	F6.3	Carbon monoxide data (PPMV); ave for 128 sec preceding recording
294	COATAG	A1	Tag for COA*

Table A-II Completed

Bytes	Fortran Name	Fortran Format	Parameter Description, Units, and Comments
295-300	COSD	F6.3	Carbon monoxide std deviation (PPMV); for 128 sec preceding recording
301	COSTAG	A1	Tag for COSD*
302-311	PD1	1PE10.3	Particle density for particles > D1 (particles/M**3)
312	PDTAG1	A1	Tag for PD1*
313-322	PD2	1PE10.3	Particle density for particles > D2 (particles/M**3)
323	PDTAG2	A1	Tag for PD2*
324-333	PD3	1PE10.3	Particle density for particles > D3 (particles/M**3)
334	PDTAG3	A1	Tag for PD3*
335-344	PD4	1PE10.3	Particle density for particles > D4 (particles/M**3)
345	PDTAG4	A1	Tag for PD4*
346-355	PD5	1PE10.3	Particle density for particles > D5 (particles/M**3)
356	PDTAG5	A1	Tag for PD5*
357-361	CLSEC	F5.0	Time in clouds (sec) during 255 sec preceding recording
362-365	CLAYR	F4.0	Number of cycles in and out of clouds (layers) during 255 sec preceding recording
366	CLTAG	A1	Tag for CLSEC and CLAYR; if CLSEC > 0, CLTAG="C"*
367-373	TRPRMB	F7.2	Tropopause pressure in hectopascals (mb)
374	TPTAG	A1	If TPTAG = " ", TRPRMB from 12 hour interpolation If TPTAG = "L", TRPRMB from 24 hour interpolation If TPTAG = "E", TRPRMB from nearest NMC reporting period If TPTAG = "M", NMC data is not available See the report text for a complete description of TPTAG criteria
375-381	DELP	F7.2	DELP = TRPRMB - PAMB, in hectopascals (mb)
382-387	TRPRHM	F6.0	Tropopause height in meters (from TRPRMB assuming std. atm.)
388-394	DELHGT	F7.0	DELHGT = ALTMAV - TRPRHM, in meters
395	GMTTAG	A1	Tag for TIME*
396-512		117A1	SPARES

*If TAG="M", corresponding data field will be zero; the "M" tag is used whenever data are not available or an instrument is in a calibration mode.

Table A-III Format for TRPR Records

Bytes	Fortran Name	Fortran Format	Parameter Description, Units, and Comments
1-4	RECID	A4	RECID = "TRPR"
5	HEMIS	A1	HEMIS= "N" for Northern Hemisphere
6-11	DATE	3I2	Date of Observation; Mo=6-7; Da=8-9; Yr=10-11
12-15	TIME	2A2	GMT of Observation; Hr=12-13; Min=14 - 15
16	NBLOCK	I1	NBLOCK = Block Counter this data array
17-18	ISTART	I2	ISTART = 1+(NBLOCK-1)*10
19-20	ISTOP	I2	ISTOP = NBLOCK*10 for NBLOCK = 1-6;ISTOP = 65 for NBLOCK=7
21-22	JSTART	I2	JSTART = 1
23-24	JSTOP	I2	JSTOP = 65
25-30	SCALE	E6.1	Scale factor for TROP(I,J)
31-43	A	E13.6	Base for TROP(I,J)
44-100		57I1	Spares
101-4000	ELE(I,J)	650I6	Tropopause Pressures in hectopascals (mb), TROP(I,J)=ELE(I,J)*SCALE+A where: ((ELE(I,J),I = ISTART,ISTOP),J = JSTART,JSTOP) Note that in the seventh block of each array only bytes 101-2050 are needed.
4001-4096		96I1	Spares

APPENDIX B - LATITUDE AND LONGITUDE FROM NMC COORDINATES

The tropopause pressure data included in GASP TRPR records are given at each of the 4225 points on the NMC 65 X 65 grid, a square matrix transformed from a polar stereographic map of the Northern Hemisphere. In the NMC coordinates the North Pole is the point (33,33), with the 10 deg E - 170 deg W meridian given by the line YJ = 33, and the 100 deg E - 80 deg W meridian given by the line XI = 33. The transformation from this coordinate system to latitude (deg N or S) and longitude (deg E or W) is as follows:

Let $R^2 = ((XI-33)^2 + (YJ-33)^2)/RHO^2$

where RHO = 31.2043

The Latitude (deg) is given by

$$THETA = (180/PI)\ \arcsin((1-R^2)/(1+R^2))$$

If THETA > 0, LAT = THETA and LATAG = "N"

If THETA < 0, LAT = -THETA and LATAG = "S"

The Longitude (deg) is given by

$$PHI = -(10 + (180/PI)\ \arctan((YJ-33)/(XI-33))$$

If -190 < PHI < -180 , Long = PHI + 360 and LONGTAG = "W"

If -180 < PHI < 0 , LONG = -PHI and LONGTAG = "E"

If 0 < PHI < 170 , LONG = PHI and LONGTAG = "W"